


ecodynamics group Università degli Studi di Siena

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27/09/2012 LECTURE @ WIMEK, Wageningen University (NL)

Via della Diana 2A - 53100 SIENA (Italy) - tel. 0577 232003 - fax. 0577 232004 - e-mail: ecodynamics@unisi.it

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**SUSTAINABILITY and TIME**



*The main novelty of technology is the acceleration and velocity of time.*

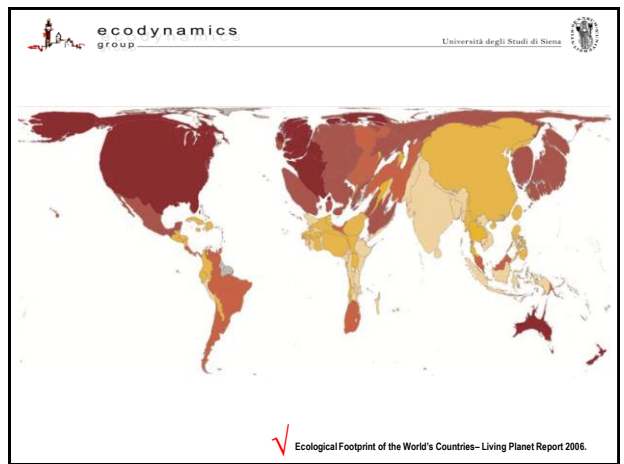
*Time in technology is different from cosmic time and human time.*

*It's as if there were two phases between technology and life, because the time and rhythm of human beings and of nature are different, and the acceleration provoked by technology breaks this rhythm.*

**TWO VELOCITIES of TECHNOLOGY and NATURE**

✓ A. Pérez-Esquivel, R.M. Pulselli, F. Rossi. The two velocities of technology and nature. *Int. J. of Ecodynamics* 2(2) 83-87 2007.

RICCARDO M. PULSELLI - Tel. + 39 (0)577 232044 - Fax. +39 (0)577 232004 - pulselli@unisi.it



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### LIVING PLANET REPORT 2012

**BIOCAPACITY: 12 billion Gha**  
1.8 Gha per capita (3.2Gha in 1961)

**FOOTPRINT: 18.2 billion Gha**  
2.7 Gha per capita

2012 25AUG | 2007 09OCT | 1966 31DEC  
 2009 28SEP

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### HISTORICAL TIME – BIOLOGICAL TIME

Dominant economic theory, based as it is on mechanic principles, remains ignorant of the law of entropy and the role of the time variable.

Not only is economics ignorant of these concepts, but it introduces another concept which can be summed up as «time is money». Progress is measured by speed of production.

It has even been suggested that the faster we use up nature's resources, the greater the advance of progress.

**This technological-economic concept of time is exactly the opposite to «entropic time».**

✓ Tiezzi, E., 2003. The End of Time. WITpress. Southampton. (translated from: Tiezzi, E., 1984. Tempi Storici. Tempi Biologici).

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### SUSTAINABILITY LAWS

*Renewable resources should be consumed at a rate that enables nature to regenerate them (Principle of Sustainable Yield)*

*Production of goods should not produce wastes that cannot be absorbed by the system in a reasonably brief time but accumulate (Principle of Absorbing Capacity)*

✓ Daly, H.E., *Steady State Economics: The Economics of Biophysical Equilibrium and Moral Growth*. W.H. Freeman: San Francisco, CA, 1977.

✓ Daly, H.E., *Toward some operational principles of sustainable development*. *Ecological Economics*, 2, pp. 1-6, 1990.

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### ENTROPY and the SECOND LAW

**It is impossible to transform an amount of heat completely into work.**

**No heat engine can be 100% thermodynamically efficient.**

**To make a machine work, heat is always released to a cold sink.**

**Once released heat cannot be used any more unless a colder sink becomes available**

**Every energy transformation into work determines a loss of energy quality (work capacity)**

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### ENTROPY and THERMODYNAMIC EQUILIBRIUM

1865 – **ENTROPY = energy flows dissipated, lost, no longer available**  
(εντροπή = change, evolution, confusion, disorder)

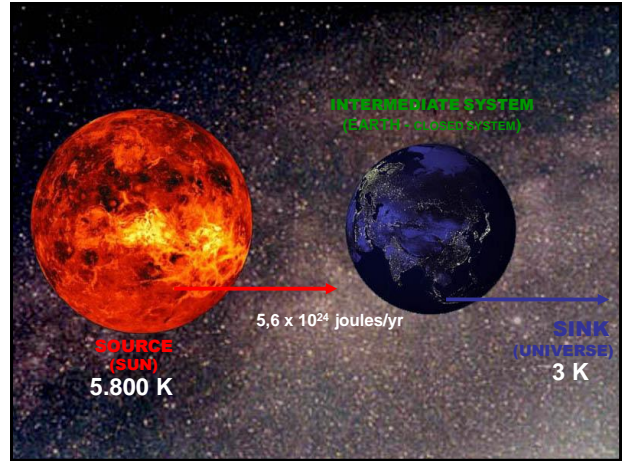
Every energy transformation determines an increase of entropy.

Entropy measures the spontaneous tendency of energy to be progressively stored at lower temperature.

Isolated systems tends to thermodynamic equilibrium (maximum entropy).

Entropy of the Universe tends to increase towards a maximum (equilibrium).

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### DISSIPATIVE STRUCTURES – FAR FROM EQUILIBRIUM SYSTEMS

SOURCE

→

INTERMEDIATE SYSTEM

→

SINK

SUBSYSTEM 1:  
 $dS_{ss}$

SUBSYSTEM 2:  
 $dS_{int}$

$dS_{ss} + dS_{int} \geq 0$

$dS_{ss} > 0$

$-dS_{int} \leq dS_{ss}$

1) a **SOURCE** of LOW ENTROPY is as necessary as the **SINK** into which high entropy must be discharged;

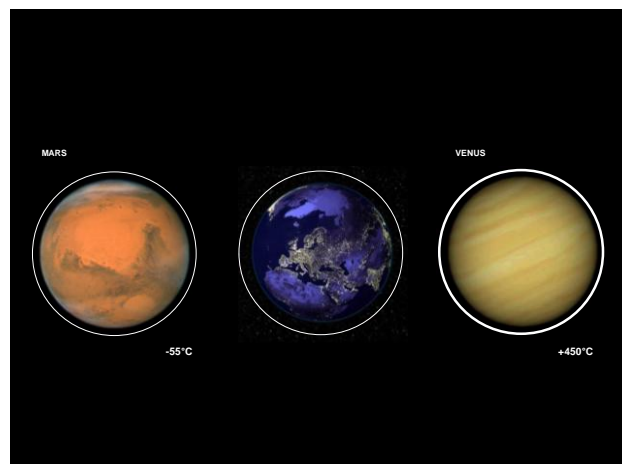
2) a **CONTINUOUS FLOW** through the system enables any intermediate system to survive, develop and increase in complexity.

"The flow of energy from the source to the sink will always involve an **increase in entropy** whereas the **entropy of the intermediate system can decrease** if there is an energy flow"

**HAROLD MOROWITZ 1979.**

✓ Morowitz, H., 1979. Energy flow in biology. Ox Bow Press, Woodbridge, Connecticut.


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**DISSIPATIVE STRUCTURES – FAR FROM EQUILIBRIUM SYSTEMS**




**SOURCE** → **INTERMEDIATE SYSTEM** → **SINK**

low entropy → high entropy → low entropy

*a SOURCE of LOW ENTROPY is as necessary as the SINK into which high entropy must be discharged; a CONTINUOUS FLOW through the system enables any intermediate system to survive, develop and increase in complexity.*

**SOURCE-SINK MODEL** ✓ Morowitz, H., 1979. Energy flow in biology. Ox Bow Press, Woodbridge, Connecticut.

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**DISSIPATIVE STRUCTURE**

*DISSIPATIVE STRUCTURES are thermodynamic systems, open to energy and matter, that selforganize towards higher complexity and organization of matter, creating order out of chaos.*

✓ Prigogine I. From being to becoming. Time and complexity in the Physical Sciences. Freeman. San Francisco 1980.


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**DISSIPATIVE STRUCTURES AND THE CITY**

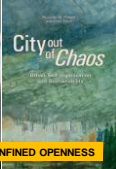


**SELF-ORGANIZATION**

*Organization emerges on a macroscopic space-time scale that is many times bigger than microscopic interactions between elements.*

✓ G. Nicolis. Physics of Far-From-Equilibrium Systems and Self-organization. (Ed.) P. Davies. The New Physics. Cambridge University Press, New York 1989.

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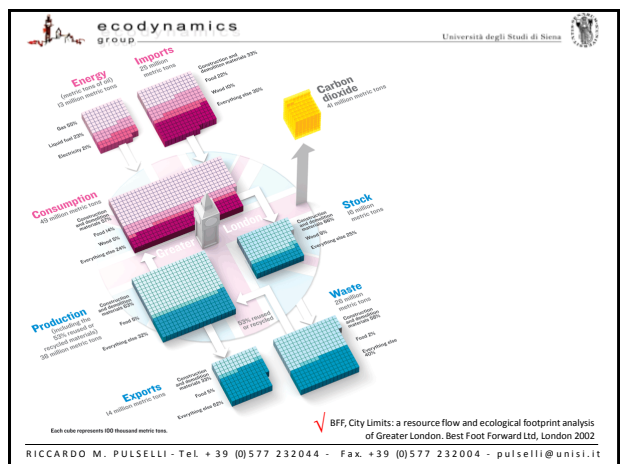
**CONFINED OPENNESS**

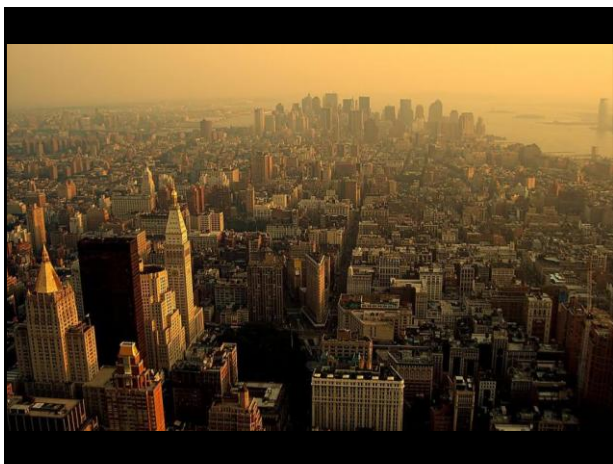
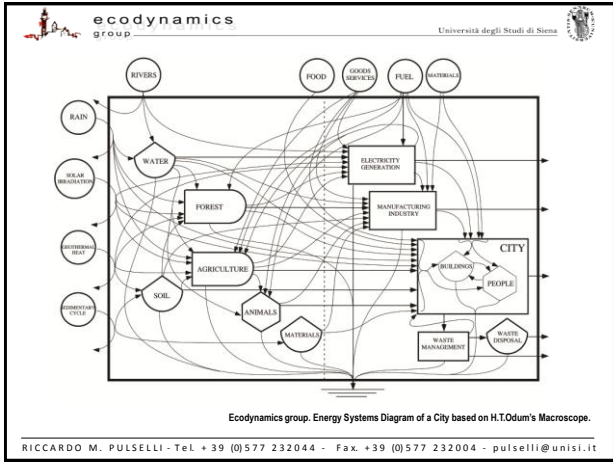
*The most simple example of dissipative structures that we can evoke by analogy is the city.*

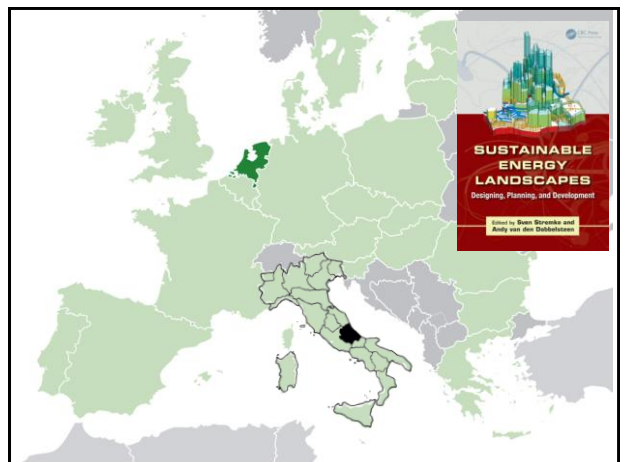
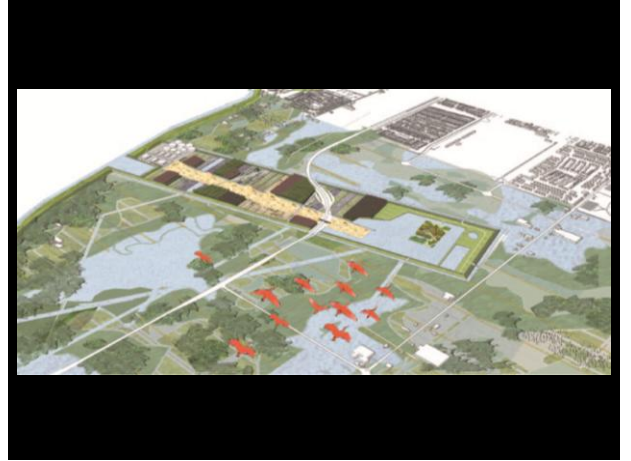
*A city is different from the countryside that surrounds it; the roots of its individuation lie in the relations it entertains with the adjacent countryside: if the countryside was eliminated, the city would disappear.*

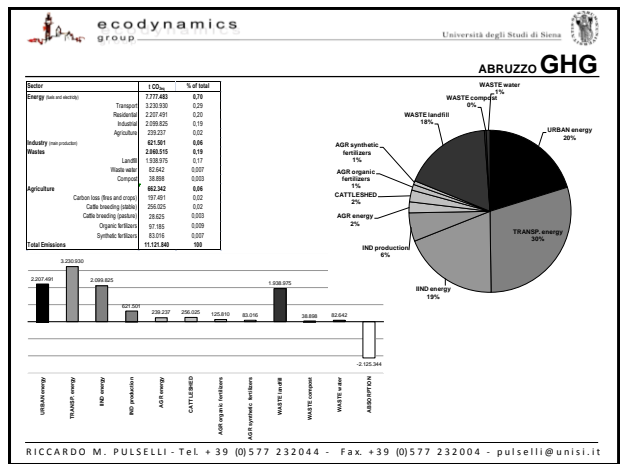
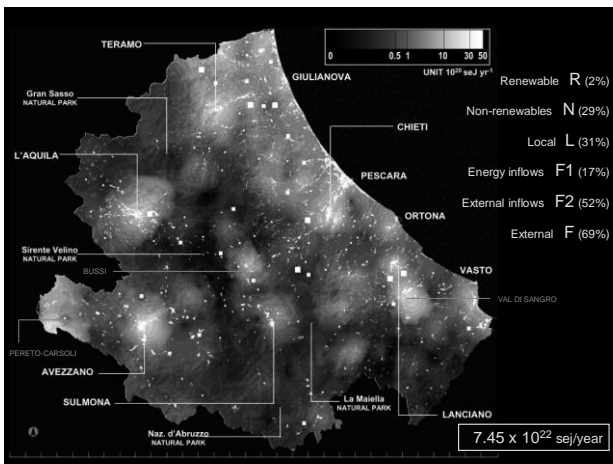
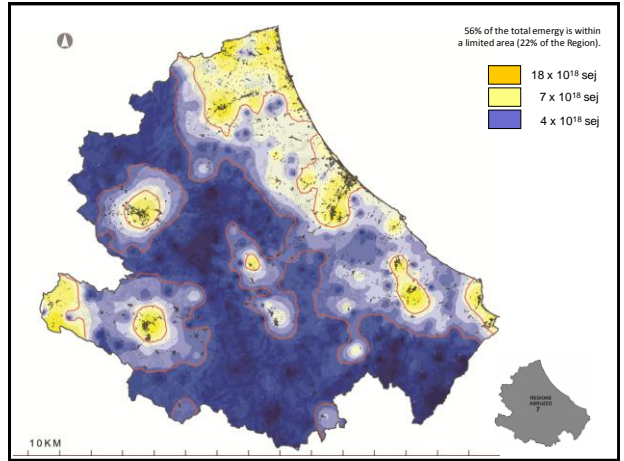
✓ I. Prigogine & L. Stengers. La Nouvelle Alliance. Métamorphose de la Science. Gallimard, Paris 1979.

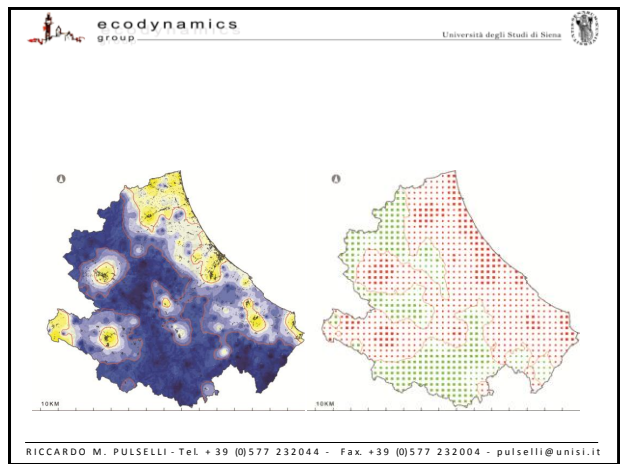
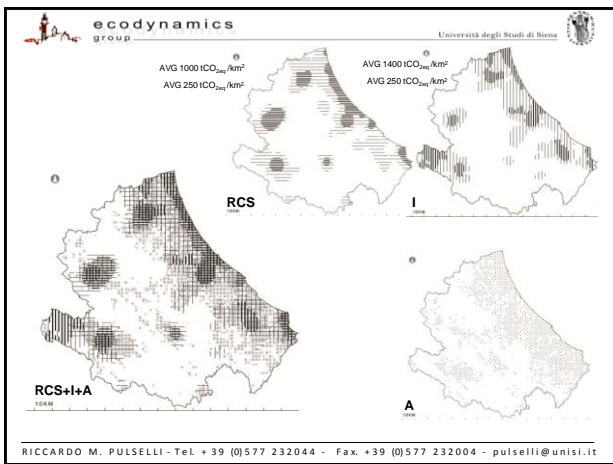
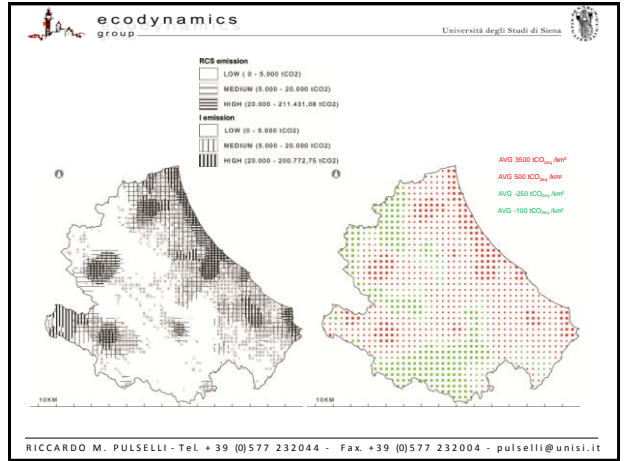
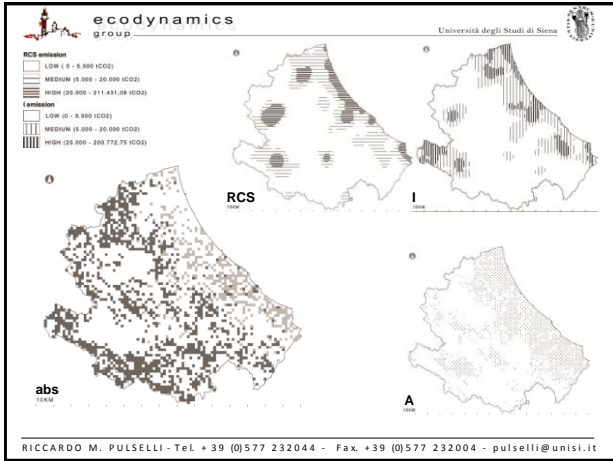
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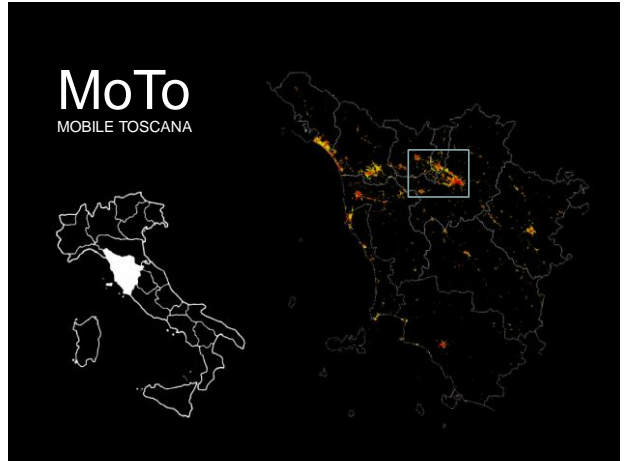
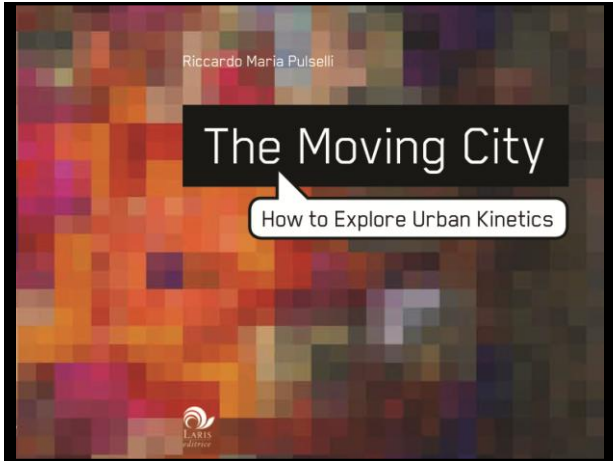


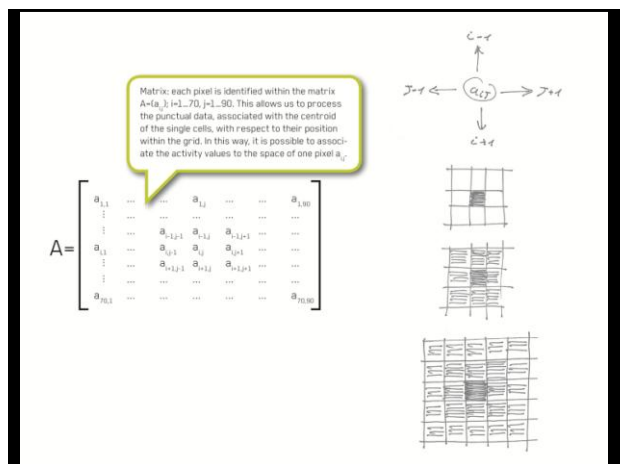
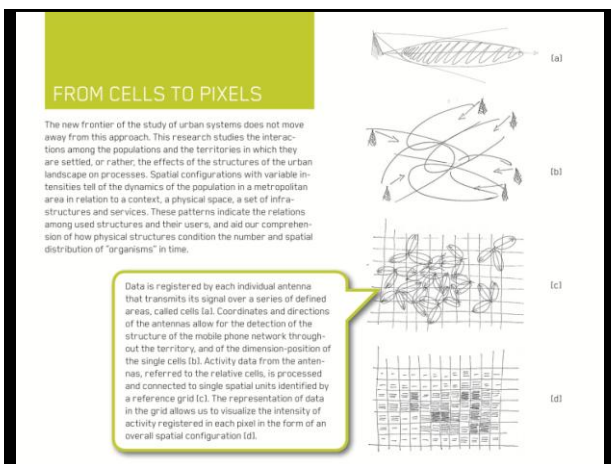
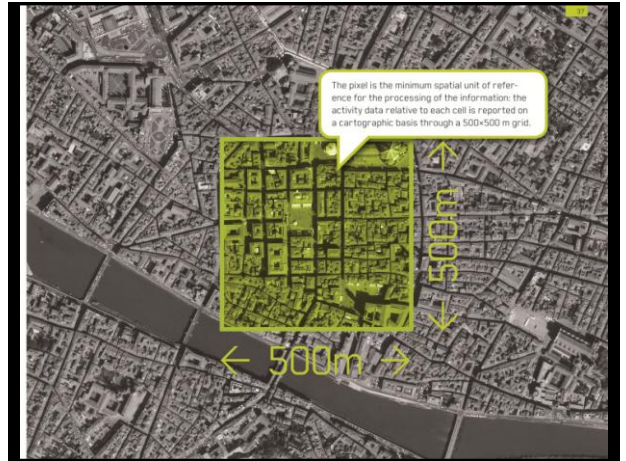
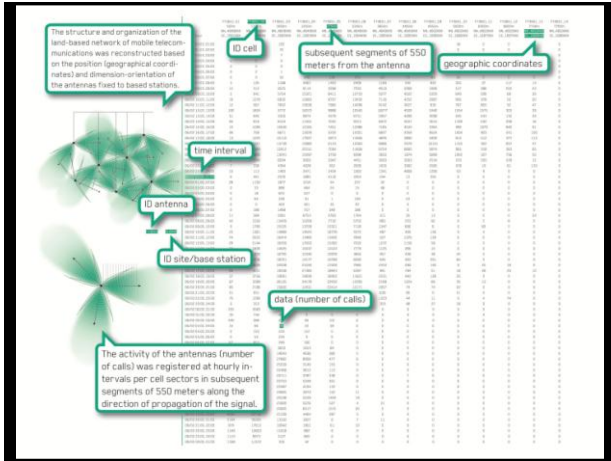












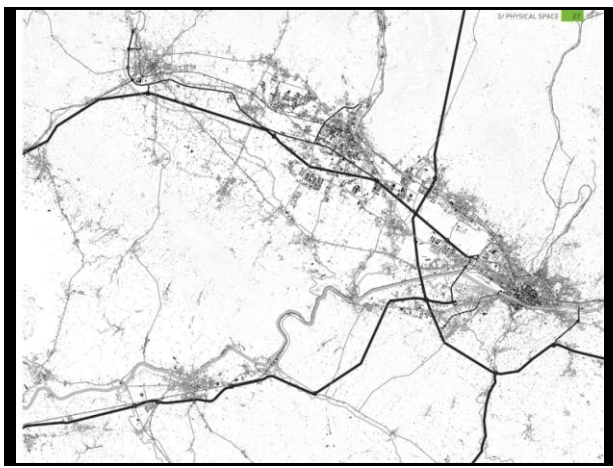
Algorithm: in order to reduce the level of approximation in georeferencing data, starting with the values referred to the single pixels, a procedure is applied that is inspired by the spatial processing techniques of the cellular automata. The initial data scattered in each pixel is summed, in a limited percentage, with the data in the pixels adjacent to the inside of a matrix grid 70x90. The calculation, performed in two times,  $t_1$  and  $t_2$ , processes the initial data  $a_{i,j}$  (number of calls / hour) within the matrix  $A=(a_{i,j}), i=1...70, j=1...90$ . The algorithm, applied to each pixel, allows us to obtain, starting with discrete data, a configuration that is continuous and diffused in space.

$\forall i=1...70, j=1...90 \gg$

$$a_{i,j}^{t_1} = a_{i,j} + 0,3 \sum_{k=j-1}^{j+1} a_{h,k}$$

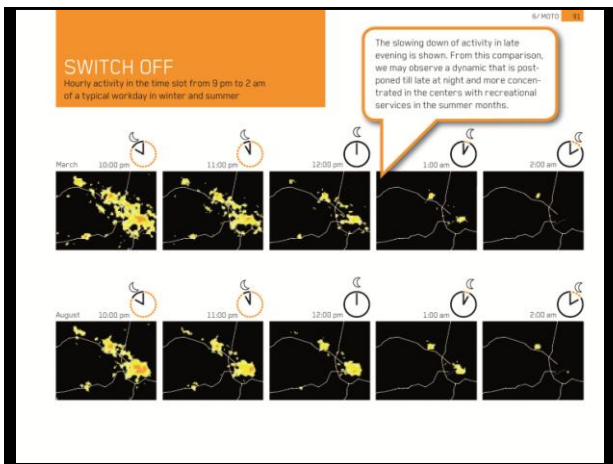
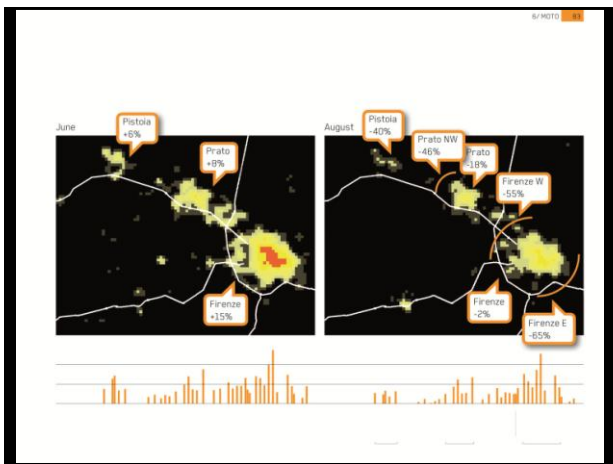
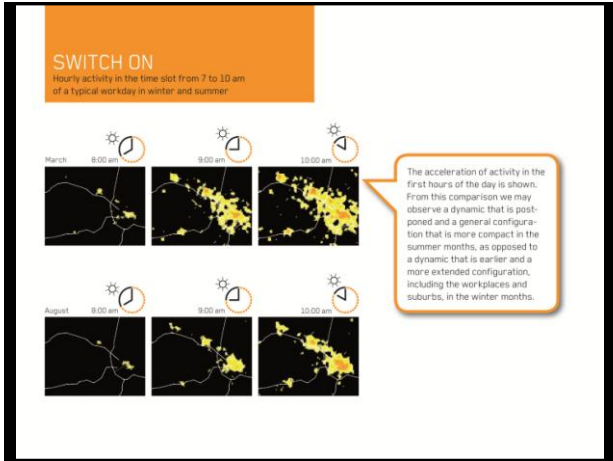
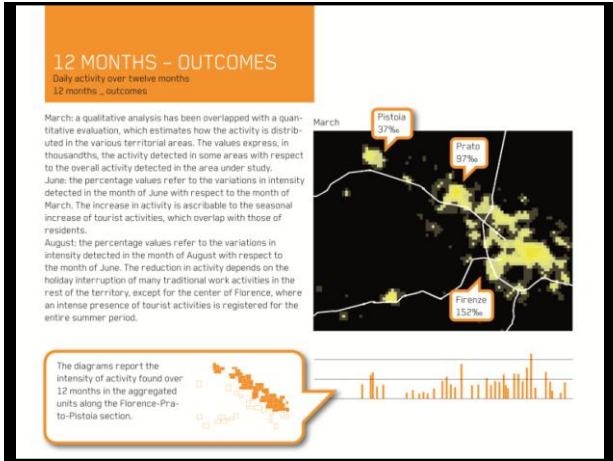
$$a_{i,j}^{t_2} = a_{i,j}^{t_1} + 0,2 \sum_{k=j-1}^{j+1} a_{h,k}^{t_1}$$

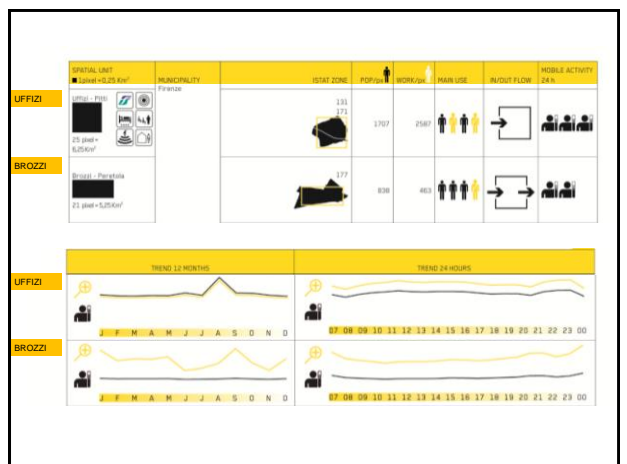
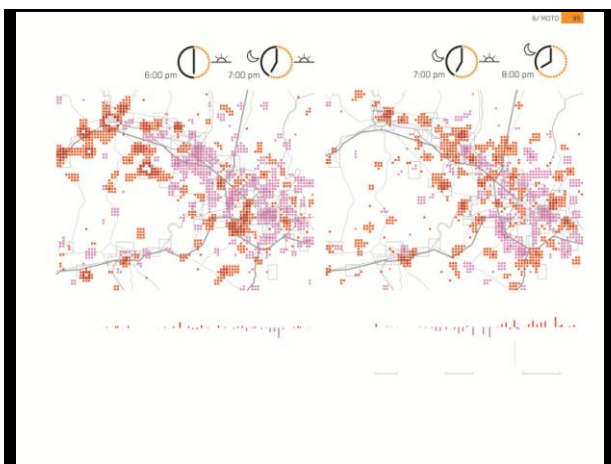
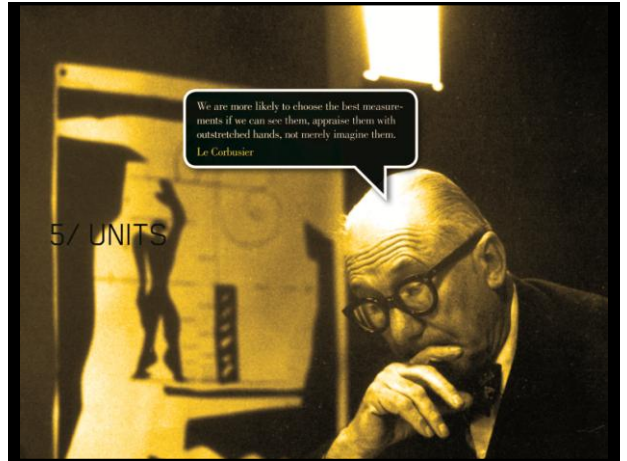
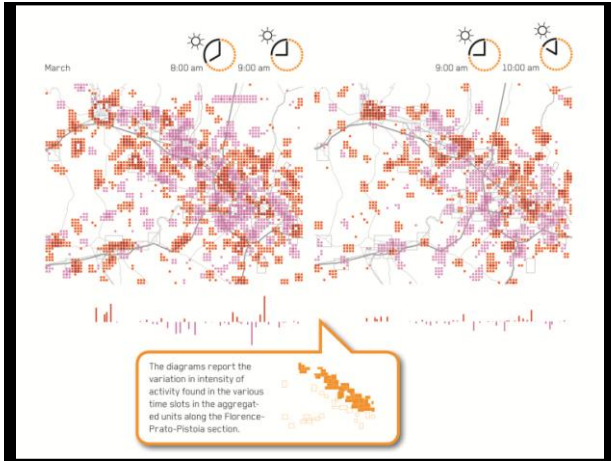
$\forall h \in \{i-1, i, i+1\} \quad \forall (h,k) \in (i,j)$

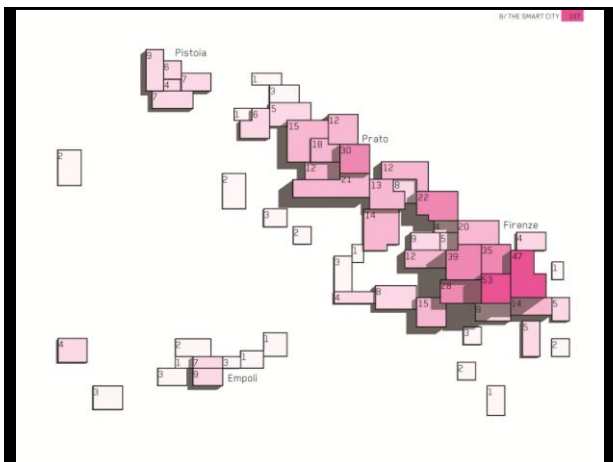
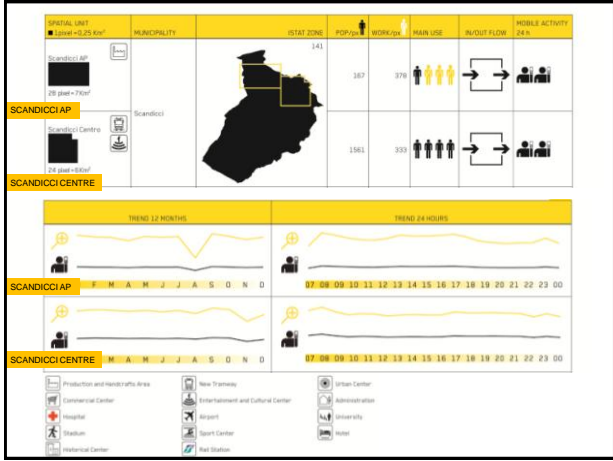


The 45x35 km area is transformed into a grid of 90x70 pixels. 6300 pixels make up the reference grid for processing information.

pixel/ minimum spatial unit







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THANK YOU

via della Diana 2A - 53100 SIENA (Italy) - tel. 0577 232003 - fax 0577 232004 - e-mail ecodynamics@unisi.it